INDOOR AIR QUALITY ASSESSMENT

Shutesbury Town Hall
1 Cooleyville Road
Shutesbury, Massachusetts

Prepared by:
Massachusetts Department of Public Health
Center for Environmental Health
Emergency Response/Indoor Air Quality Program
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Background/Introduction

At the request of David Dann, Town Administrator, the Massachusetts Department of Public Health (MDPH), Center for Environmental Health (CEH) provided assistance and consultation regarding indoor air quality at the Shutesbury Town Hall (STH), 1 Cooleyville Road, Shutesbury, Massachusetts. Concerns about odors/water penetration in the basement prompted the request. On March 18, 2005, a visit was made to this building by Michael Feeney, Director of Emergency Response/Indoor Air Quality (ER/IAQ), CEH, to conduct an indoor air quality assessment.

The STH is a two-story, clapboard-sided, wood frame structure. The building was constructed as a school in 1950. The upper story contains town offices. The lower floor contains a meeting room, kitchen, elderly affairs room, furnace room and a storeroom that is connected to a room with a water tank. Windows appeared to be original wooden sash windows and are openable throughout the building.

Methods

Air tests for carbon dioxide, temperature and relative humidity were taken with the TSI, Q-Trak, IAQ Monitor Model 8551. CEH staff also performed visual inspection of building materials for water damage and/or microbial growth.

Results

The STH has an employee population of 5 and is visited by approximately 10 to 20 people daily. Tests were taken during normal operations and results appear in Table 1.

Discussion

Ventilation

It can be seen from the tables that carbon dioxide levels were below 800 parts per million (ppm) of air in all areas. Please note that most rooms were unoccupied during the assessment, which can greatly reduce carbon dioxide levels. Carbon dioxide levels in the building would be expected to be higher with increased population.

The upper floor does not have a mechanical ventilation system. Heat is provided by radiators. Ventilation is provided by opening windows. On the lower floor, mechanical ventilation was originally provided by a unit ventilator (univent) system (Picture 1). Univents draw air from outdoors through a fresh air intake located on the exterior wall of the building and return air through an air intake located at the base of the unit (Figure 1). Fresh and return air are mixed, filtered, heated and provided through an air diffuser located in the top of the unit. Univents were deactivated and appeared inoperable at the time of the assessment. MDPH staff examined the interior of the univent in the meeting room and found the fresh air intake blocked with newspaper (Pictures 2 and 2A). In this condition, the univent does not provide fresh air supply, but rather recirculates air only. In order for univents to provide fresh air as designed, intakes, air diffusers and return vents must remain free of obstructions. Importantly, these units must be activated and allowed to operate while rooms are occupied.

Exhaust ventilation on the lower floor is provided by unit exhaust vents (UEVs) (Picture 3). This equipment contains two fans that draw air from the building. The presence of rodent nesting materials inside the axial fan (Picture 4) of one of the UEVs indicates that the UEV has not been used for some time. Without functional mechanical fresh air supply or exhaust ventilation, environmental pollutants can accumulate within the building and lead to air quality/comfort complaints.

During summer months, air exchange is facilitated by the use of openable windows. The building was configured in a manner to use cross-ventilation to provide comfort for building occupants. The building is equipped with windows on opposing exterior walls. Open hallway doors maintain a pathway for airflow. This design allows for airflow to enter an open window, pass through a room and an open door, enter the hallway, pass through the opposing room door, into that room and exit the building on the leeward side (opposite the windward side) (Figure 2). With all windows and hallway doors open, airflow can be maintained in a building regardless of the direction of the wind. This system fails if the windows or doors are closed (Figure 3). Most hallway doors in the building were open during the assessment.

To maximize air exchange, the MDPH recommends that both supply and exhaust ventilation operate continuously during periods of school occupancy. In order to have proper ventilation with a mechanical supply and exhaust system, the systems must be balanced to provide an adequate amount of fresh air to the interior of a room while removing stale air from the room. It is recommended that HVAC systems be re-balanced every five years to ensure adequate air systems function (SMACNA, 1994). The date of the last balancing of these systems was not available at the time of the assessment. The mechanical ventilation systems, in their current condition, cannot be balanced.

The Massachusetts Building Code requires a minimum ventilation rate of 20 cubic feet per minute (cfm) per occupant of fresh outside air or have openable windows in each room (SBBRS, 1997; BOCA, 1993). The ventilation must be on at all times that the room is occupied. Providing adequate fresh air ventilation with open windows and maintaining the temperature in the comfort range during the cold weather season is impractical. Mechanical ventilation is usually required to provide adequate fresh air ventilation.

Carbon dioxide is not a problem in and of itself. It is used as an indicator of the adequacy of the fresh air ventilation. As carbon dioxide levels rise, it indicates that the ventilating system is malfunctioning or the design occupancy of the room is being exceeded. When this happens a buildup of common indoor air pollutants can occur, leading to discomfort or health complaints. The Occupational Safety and Health Administration (OSHA) standard for carbon dioxide is 5,000 parts per million parts of air (ppm). Workers may be exposed to this level for 40 hours/week, based on a time-weighted average (OSHA, 1997).

The Department of Public Health uses a guideline of 800 ppm for publicly occupied buildings. A guideline of 600 ppm or less is preferred in schools due to the fact that the majority of occupants are young and considered to be a more sensitive population in the evaluation of environmental health status. Inadequate ventilation and/or elevated temperatures are major causes of complaints such as respiratory, eye, nose and throat irritation, lethargy and headaches.

Temperature readings were measured in a range of 64º F to 67º F, which were below the MDPH recommended comfort range in all areas. The MDPH recommends that indoor air temperatures be maintained in a range of 70º F to 78º F in order to provide for the comfort of building occupants. In many cases concerning indoor air quality, fluctuations of temperature in occupied spaces are typically experienced, even in a building with an adequate fresh air supply. Lack of a functional ventilation system can exacerbate the lack of control over thermal comfort.

The relative humidity measured in the building ranged from 18 to 28 percent, which was below the MDPH recommended comfort range in all areas surveyed. The MDPH recommends a comfort range of 40 to 60 percent for indoor air relative humidity. Relative humidity levels in the building would be expected to drop during the winter months due to heating. The sensation of dryness and irritation is common in a low relative humidity environment. Low relative humidity is a very common problem during the heating season in the northeast part of the United States.

Microbial/Moisture Concerns

A distinct mold odor was detected along the north wall of the meeting room. The odor was traced to a wall vent which opens into a storeroom with a sump pump in its floor (Picture 5). A water tank and associated pipes are also located in a small room (the water service room), which shares a wall with the meeting room. The ceiling of the water service room has a manhole that leads outdoors. The water service room also contains a passive vent (Picture 6) that opens into the meeting room. The vent was covered by a wall hanging (Picture 7).

A number of materials that could support mold growth and/or conditions that provide moisture to support mold growth were observed in the storeroom and water service room. These included:

- The sump pump installed in the floor to remove water accumulation.

- Damaged cement along the walls of the foundation that are in contact with soil, indicating significant water penetration through the wall.
- The water holding tank and insulated pipes in the water service room. Due to temperature differential, it is likely that the surface of the water tank and pipes produce condensation during hot, humid weather.
- Spaces around the manhole cover, which can allow for movement of cold air into the space in winter and hot/moist air in the summer. The door between the storeroom and water service room would be subject to condensation due to the temperature differential.
- Since the lower floor is not air-conditioned during the summer, surfaces in direct contact with soil and materials in such surfaces would be prone to condensation.

Condensation is the collection of moisture on a surface that has a temperature below the dew point. The dew point is a temperature that is determined by air temperature and relative humidity. For example, at a temperature of 76^{o}F and a relative humidity of 30 percent, the dew point for water to collect on a surface is approximately 43^{o}F. At a temperature of 85^{o}F and a relative humidity of 90 percent, the dew point for water to collect on a surface is approximately 82^{o}F. Therefore, if a surface has a temperature under 83^{o}F, water vapor will form droplets on that surface. Surfaces below grade that are in contact with earth tend to be substantially cooler than the air temperature, making them prone to generating condensation.

Moisture penetration through the storeroom wall is likely due to water accumulation against the foundation at the front (uphill side) of the building. As part of a renovation, a cement walkway was installed along the front and eastern sides of the building. This walkway extends from the front door to a point roughly above the water service room. The sealant inserted into the seam between the foundation wall and walkway appears to be deteriorating (Picture 8). Missing/damaged sealant can allow moisture to penetrate into this crack and accumulate against the foundation wall, subsequently leading to moisture penetration into the storeroom. In addition the walkway is slanted to drain onto the bare soil above the water service room (Picture 9). Water damage and efflorescence was observed in the storeroom and water service room. Efflorescence is a characteristic sign of water damage to building materials such as brick or plaster, but it is not mold growth. As moisture penetrates and works its way through mortar and brick, water-soluble compounds dissolve, creating a solution. As the solution moves to the surface of the brick or mortar, water evaporates, leaving behind white, powdery mineral deposits. Conditions observed indicate that water has penetrated into the storeroom and water service room.

A number of materials were seen in the storeroom/water service room that are prone to mold colonization. Water damaged cardboard, cloth, books, paper and other porous materials can all support mold colonization if moistened for an extended period of time. Water damaged materials such as cardboard and paper were also noted in the senior room (Picture 10). The surface of the door separating the storeroom and water service room was colonized with mold (Picture 11). Each of these conditions, in combination with high ambient temperatures during the summer, increased relative humidity and possible water sources, may contribute to moistening of porous materials.

The US Environmental Protection Agency and the American Conference of Governmental Industrial Hygienists (ACGIH) recommends that porous materials (carpeting, ceiling tiles, etc.) be dried with fans and heating within 24 to 48 hours of becoming wet (US EPA, 2001; ACGIH, 1989). If porous materials are not dried within this time frame, mold growth may occur. Water-damaged porous materials cannot be adequately cleaned to remove mold growth. The application of a mildewcide to moldy porous materials is not recommended.

The passive vents to the storeroom and water service room that open to the meeting room and senior room (Pictures 12 and 13) serve as pathways for odors and other mold related particulates to migrate into occupied areas. Typically, passive air vents are used to provide make-up air for a mechanical exhaust vent. No mechanical exhaust vents could be identified in this area by MDPH staff. A mechanical vent of this nature would likely have to operate continuously to remove storeroom odors and more importantly, water vapor that can moisten materials.

The building has a ceiling tile system that is glued directly to the ceiling. A number of rooms had water damaged ceiling tiles. Replacement of these ceiling tiles is difficult, since their removal appears to necessitate the destruction of the tile, which can result in the aerosolization of particulates. Water damaged ceiling tiles may provide a medium for mold growth and should be replaced after a water leak is discovered and repaired.

Several rooms contained a number of plants. Moistened plant soil and drip pans can provide a source of mold growth. Plants are also a source of pollen. Plants should be properly maintained, over-watering of plants should be avoided and drip pans should be inspected periodically for mold growth.

Other Concerns

Several other conditions that can potentially affect indoor air quality were identified during the assessment. A distinct fuel oil odor was noted at the base of the stairs in the lower level. The odor was traced to the furnace room opposite the stairwell. Inside the furnace room are two tanks that were coated with oil from overfill (Picture 14). An absorbent material used to soak up oil was also observed beneath the furnace oil pump (Picture 15).

Of note was a steady stream of cold, outdoor air from a vent (Picture 16) located in the exterior wall. The vent is located in the southwestern corner of the building. The prevailing winds in Massachusetts tend to be from the west (Trewartha, 1943). In this configuration the prevailing winds would impinge on the vent on a regular basis. Air forced into the vent under windy conditions will pressurize the furnace room, which would in turn force air and other odors within the furnace room into the lower level corridor through spaces around the furnace room door. The purpose of the open vent was unclear since another ducted vent system also exists in the room that appears to provide combustion air for the furnace (Picture 17). Cold air was detected flowing from the ducted system. Combustion air is necessary for a furnace to burn fuel. Frequently an open passive vent connected to a duct with multiple turns is used to provide oxygen for the furnace while preventing/limiting pressurization of the furnace room under windy conditions. A furnace room should be either neutral pressure or depressurized as air is draw into and consumed during the combustion process.

Univents are normally equipped with filters that strain particulates from airflow. No filters were found inside the univents at the STH. With no filters, debris accumulates inside the univent (Picture 16). Accumulated debris inside a univent can obstruct airflow and may serve as a reservoir of particulates that can be re-aerosolized and distributed to occupied areas. In order to decrease aerosolized particulates, disposable filters with an adequate dust spot efficiency can be installed. The dust spot efficiency is the ability of a filter to remove particulates of a certain diameter from air passing through the filter. Filters that have been determined by ASHRAE to meet its standard for a dust spot efficiency of a minimum of 40 percent would be sufficient to reduce airborne particulates (Thornburg, 2000; MEHRC, 1997; ASHRAE, 1992). Note that increased filtration can reduce airflow produced by univents due to increased resistance, or pressure drop. Prior to any increase of filtration, a ventilation engineer should evaluate each univent to ascertain whether it can maintain function with more efficient filters.

A number of areas contained window-mounted air conditioners. This equipment is also typically equipped with filters, which should be cleaned or changed per the manufacturer's instructions to avoid the build up and re-aerosolization of dirt, dust and particulate matter.

According to town officials, the STH has a history of rodent problems, as was evidenced by nesting materials shown in Picture 4. Rodent infestation can result in indoor air quality related symptoms due to materials in their wastes. Mouse urine is known to contain a protein that is a known sensitizer (US EPA, 1992). A sensitizer is a material that can produce symptoms in exposed individuals and can cause running nose or skin rashes in sensitive individuals. Since particulates can be drawn into the air stream, univents can serve to distribute these particulates. It is important that proper filters be installed in univents to reduce this potential problem. To eliminate rodent infestation a three-step approach is necessary:

- remove rodents;
- clean waste products from the interior of the building; and
- reduce/eliminate pathways/food sources that are attracting rodents.

To eliminate exposure to allergens, rodents must be removed from the building. Please note that removal, even after cleaning, may not provide immediate relief since allergens can exist in the interior for several months after rodents are eliminated (Burge, 1995). A combination of cleaning and an increase in ventilation and filtration should serve to reduce rodent associated allergens once the infestation is eliminated.

Use of rodenticides alone cannot prevent pest and rodent problems. Food is an attractant to pests and rodents. Food was observed in the kitchen as well as the storeroom. As previously discussed, proper food storage is an integral component in maintaining sanitary conditions. Reuse of food containers is also not recommended, since food residue adhering to the surface may serve to attract pests.

A number of insect bodies were noted on top of a univent and on windowsills. Insect parts can dry and become aerosolized and may serve as a source of allergenic material for sensitive individuals. The most likely route for insect penetration into the building is through spaces around window frames. The reduction/elimination of pathways into the building should be the first step taken to prevent an insect infestation.

Finally, the basement has an abandoned water bubbler (Picture 18). It appeared that no water had been poured into these drains recently. Without water, the drain traps can dry, resulting in the loss of the airtight seal created by a wet trap. A dry trap can result in sewer gas backing up into the building under certain circumstances. Sewer gas can be irritating to the eyes, nose and throat.

Conclusions/Recommendations

In view of the findings at the time of the visit, the complaints in the meeting room are consistent with what might be encountered in an area subject to mold contamination and fuel odors. Compounding these issues is the lack of functioning mechanical ventilation. In order to address the conditions listed in the assessment, recommendations to improve indoor air quality are separated into **short-term** and **long-term** corrective measures. The **short-term** recommendations can be implemented as soon as possible. **Long-term** recommendations are more complex and will require planning and resources to adequately address overall indoor air quality concerns.

Short-Term Recommendations

Mold Contaminated Materials

1. Discard stored materials and replace building materials that appear to have mold contamination. This measure will remove actively growing mold colonies that may be present. Remove mold contaminated materials in a manner consistent with recommendations in "Mold Remediation in Schools and Commercial Buildings" published by the US Environmental Protection Agency (US EPA,

2001). Copies of this document can be downloaded from the US EPA website at: http://www.epa.gov/iaq/molds/mold_remediation.html.

2. Seal the passive vents and the storeroom door with a temporary impermeable barrier (e.g., wood, gypsum wallboard). Ensure barrier is as airtight as possible by sealing edges and frames with polyethylene plastic and duct tape. Inspect for drafts and/or light penetration to ensure airtight integrity.
3. Use local exhaust ventilation and isolation techniques to control remediation pollutants. Precautions should be taken to avoid the re-entrainment of these materials into the building.
4. Establish communications between all parties involved with remediation efforts, including building occupants, to prevent potential IAQ problems.
5. Develop a notification system for building occupants to report remediation related odors and/or issues to the building administrator. Have these concerns relayed to the contractor and/or contact person in a manner that allows for a timely remediation of the problem.
6. Schedule projects which produce large amounts of dusts, odors during unoccupied periods, when possible.
7. Relocate susceptible persons and those with pre-existing medical conditions (e.g., asthma) away from the general areas of remediation until completion, if possible.

Furnace Room

1. Examine the vented duct for adequate combustion airflow for the furnace.
2. When adequate combustion airflow from the ducted vent is established/confirmed, seal the second vent.
3. Clean oil residue from tanks and floor.
4. Render the furnace room door as airtight as possible by installing weather-stripping on the doorframe and a door sweep at the bottom of the door. Seal seams in the wall and doorframe with an appropriate, fire-rated sealant.

General Indoor Air Quality

1. Since univents are inoperable, the sole source of fresh air is through windows. In order to temper room temperature and provide fresh air, the opening of windows is recommended. Use open windows and doors throughout the building to enhance airflow during warm weather. To aid in the draw of fresh outdoor air in warm weather, use portable fans directing air out windows on the leeward side of the building. Fans positioned in this manner will serve to increase the draw of outdoor air without interfering with the natural internal airflow pattern of the building.
2. Contact a ventilation engineer to examine the univent and unit exhaust vent to ascertain whether they are repairable. In addition, the ventilation engineer should confirm that fresh air intakes exist for the univents.
3. Replace the sealant in the walkway/foundation seam at the front of the building.

4. Refrain from storing paper, cardboard or other porous materials in the storeroom until water penetration through the foundation is resolved.
5. Seal abandoned/unused water bubbler drains. Be sure to also shut off the water supply to prevent accidental flooding.
6. Clean or replace filters in window-mounted air conditioners in a manner consistent with the manufacturer's recommendations. In order to reduce airborne particulates, consider operating the air conditioners on the fan only setting during cold weather. The operation of the window-mounted air conditioners without activating the air-cooling capacity of the equipment will both provide particulate removal and increase air circulation in office space.
7. For buildings in New England, periods of low relative humidity during the winter are often unavoidable. Therefore, scrupulous cleaning practices should be adopted to minimize common indoor air contaminants whose irritant effects can be enhanced when the relative humidity is low. To control for dusts, a high efficiency particulate arrestance (HEPA) filter equipped vacuum cleaner in conjunction with wet wiping of all surfaces is recommended. Drinking water during the day can help ease some symptoms associated with a dry environment (throat and sinus irritations).
8. Avoid over-watering plants and examine drip pans periodically for mold growth. Disinfect with an appropriate antimicrobial where necessary. Consider reducing the number of plants in some areas.
9. Use the principles of integrated pest management (IPM) to rid this building of pests. A copy of the IPM recommendations (MDFA, 1996) can be downloaded

from the following website:

http://www.state.ma.us/dfa/pesticides/publications/IPM_kit_for_bldg_mgrs.pdf.

10. For further building-wide evaluations and advice on maintaining public buildings, refer to the resource manual and other related indoor air quality documents located on the MDPH's website at http://www.state.ma.us/dph/beha/iaq/iaqhome.htm.

Long Term Recommendations

1. Examine the feasibility of installing a mechanical exhaust vent in the storeroom/water service room to remove odors and water vapor.
2. Consider should be given to replacing the univent and univent exhaust vent since repair of this equipment may be difficult due to its condition.
3. Consideration should be given to regarding the front of the building to enhance water flow away from the foundation. This may include either extending the walkway beyond the edge of the foundation or removal of the walkway. The following are general recommendations that could be used to improve drainage around the front of the building:
    a. Improve the grading of the ground away from the foundation at a rate of 6 inches per every 10 feet (Lstiburek & Brennan, 2001).
    b. Install a water impermeable layer on ground surface (clay cap) to prevent water saturation of ground near foundation (Lstiburek & Brennan, 2001).
4. For removal of tiles directly adhered to the ceiling, such removal would be considered a renovation activity that can release particulates and spores in

particular, if the material is moldy. Replacement of ceiling tiles may involve glues that contain VOCs. In order to minimize occupant exposure, repairs should be done while the building is unoccupied.

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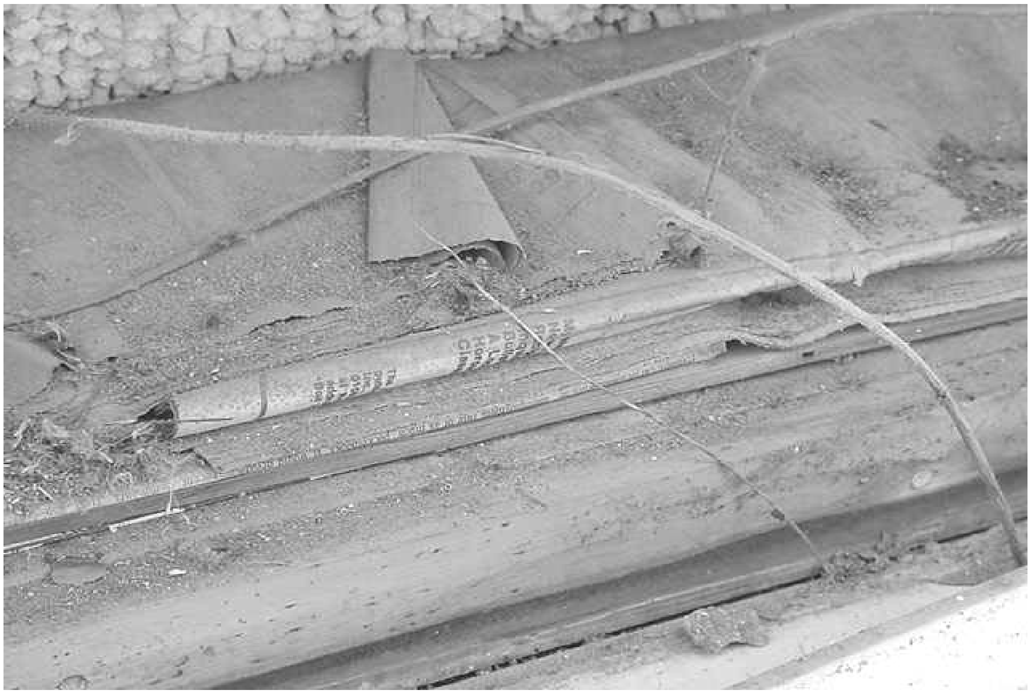
Picture 1

Univent

Picture 2

Fresh Air Intake for the Univent Was Blocked With Newspaper

Picture 2A

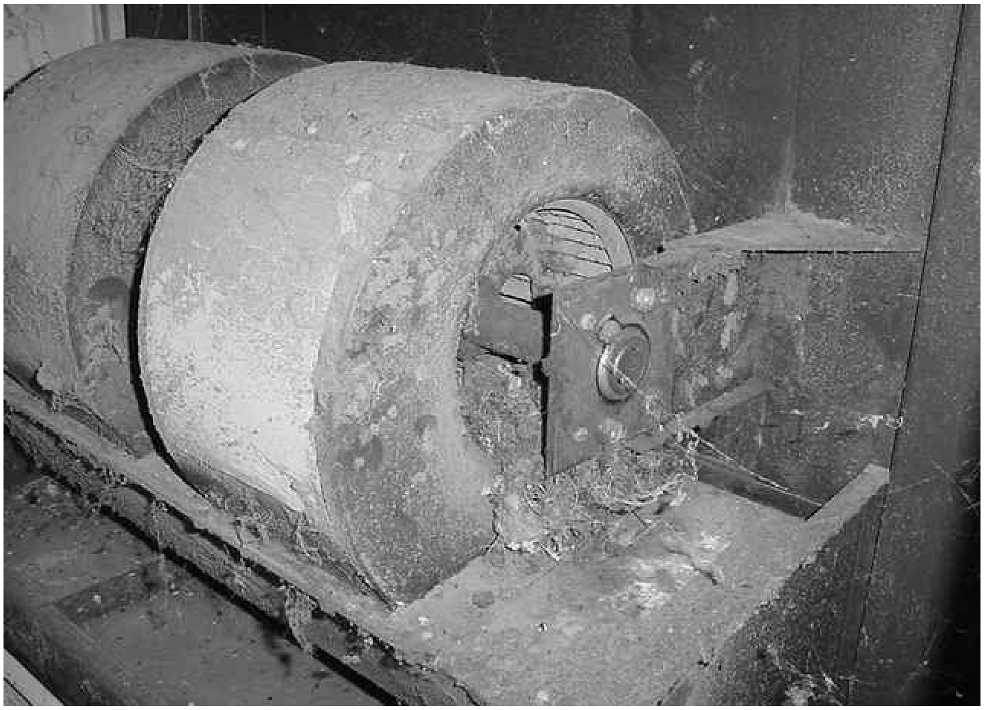


Close-Up of Picture 2

Picture 3

Unit Exhaust Vent (UEV), Behind Table (Note Air Intake Grill at Base of Cabinet)

Picture 4



Rodent Nesting Materials inside the Axial Fan of UEV

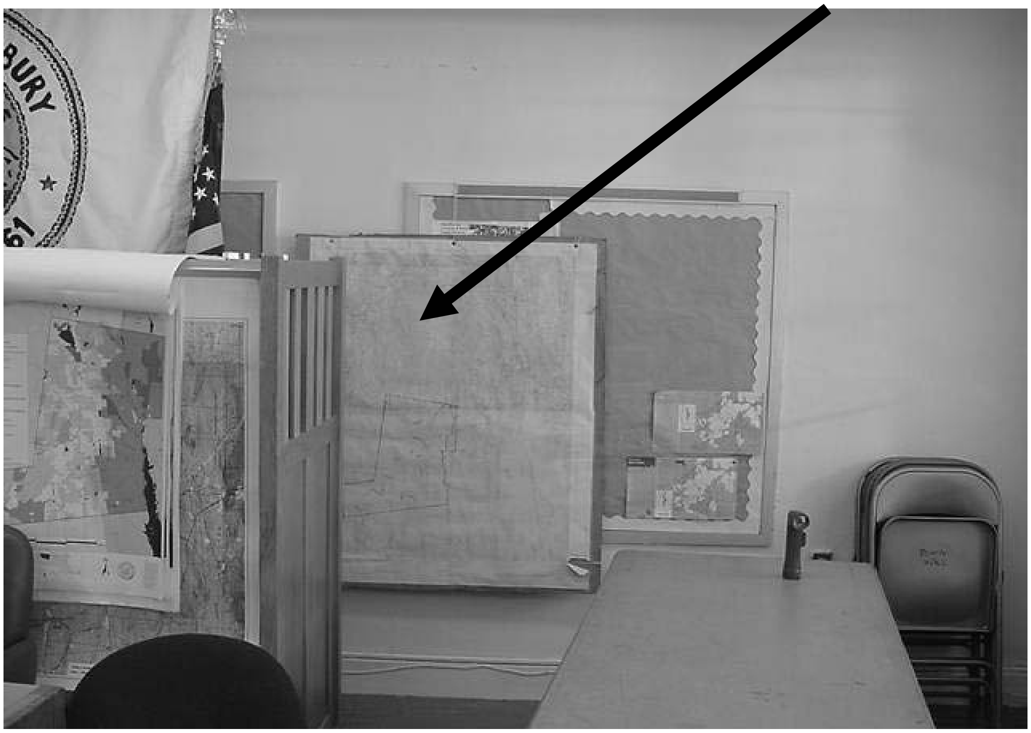
Picture 5

Storeroom Sump Pump, Note Cardboard Box over Pump

Picture 6

Water Service Room Passive Vent That was Covered by Bulletin Board

Picture 7

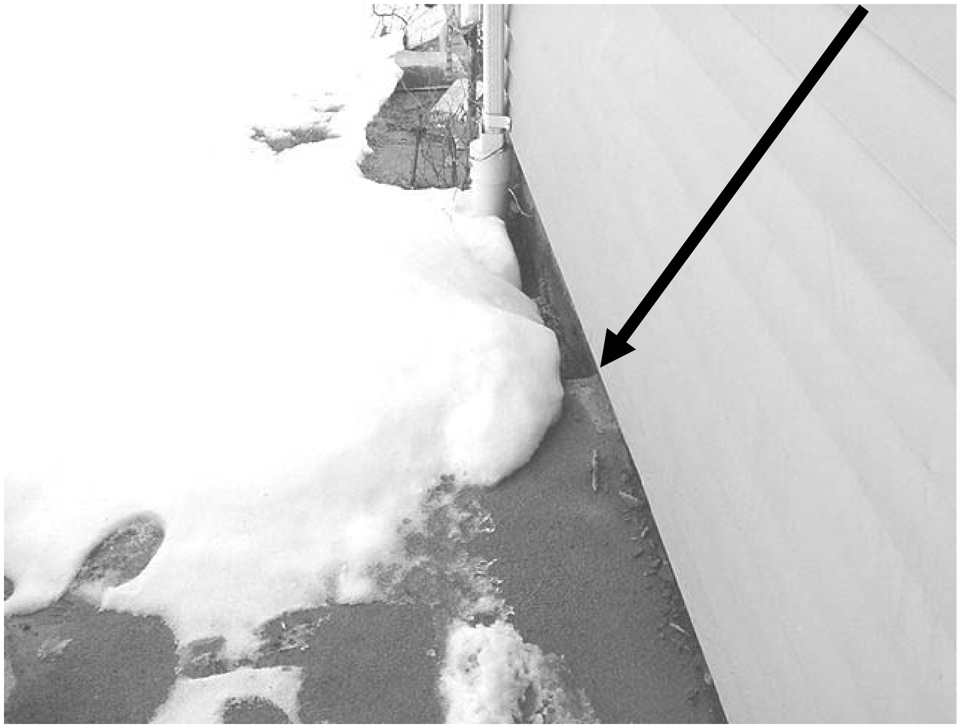


Approximate Location of Water Service Room Passive Vent

Picture 8

Damaged Sealant in Seam Foundation Wall/Walkway Seam, Northeast Section of Building

Picture 9

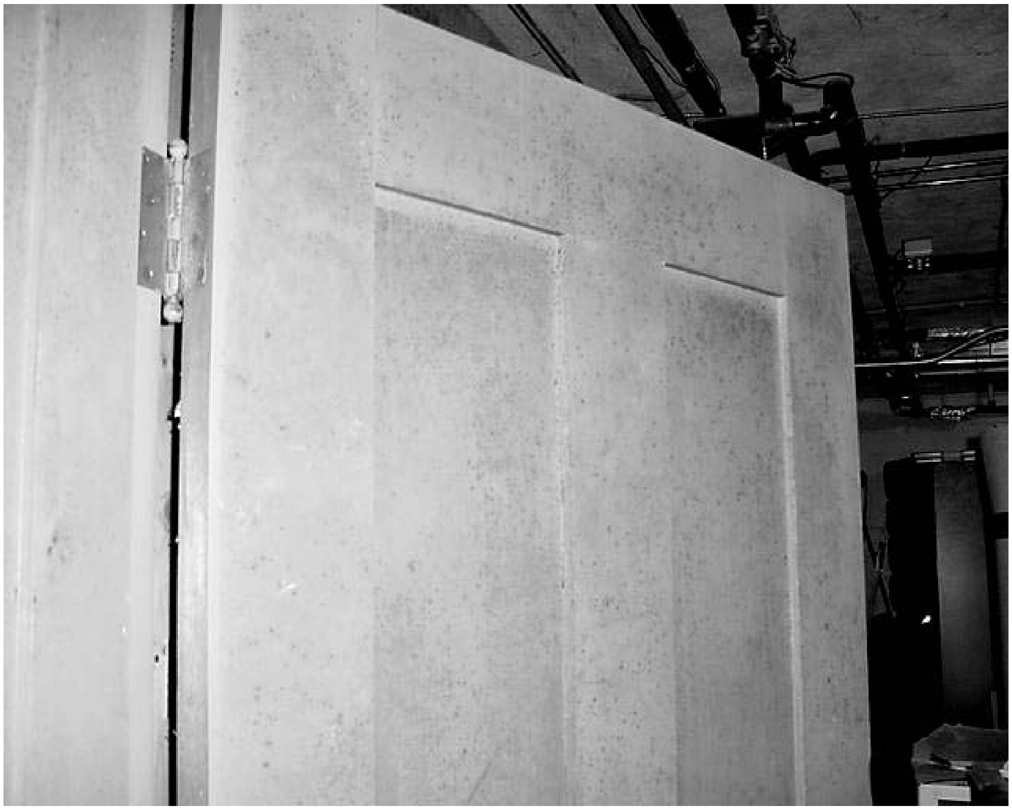


End of Walkway, Note End of Cement Walkway with Snow on Soil against Foundation (Northeast Section of Building)

Picture 10

Water Damaged Materials in Senior Room

Picture 11



Water Service Room Door with Mold Colonies

Picture 12

Passive Vent in Meeting Room

Picture 13

Passive Vent in Senior Room

Picture 14

Oil Coated Tanks

Picture 15

Absorbent Material beneath Furnace Oil Pump

Picture 16

Open Vent in Furnace Room

Picture 17

Duct for Combustion Air in Furnace Room

Picture 18

Abandoned Water Bubbler

TABLE 1
Indoor Air Test Results
Shutesbury Town Hall, Shutesbury, MA
March 18, 2005

Location	Carbon Dioxide (*ppm)	Temp. (°F)	Relative Humidity (%)	Occupants in Room	Windows Openable	Ventilation		Remarks
						Supply	Exhaust	
Outside (Background)	349	53	16					Clear, sunny day
Meeting room	394	62	24	0	Y	Y	Y	Supply vent off Exhaust vent off Musty odor near storeroom door passive vent
Senior room	359	60	23	0	Y	Y	Y	Supply vent off Exhaust vent off Passive vent to storeroom
Storeroom	413	61	26	0	N	N	N	Passive vent to meeting and senior rooms
Water service room	455	60	28	0	N	N	N	Passive vent to meeting room
Photocopier room	569	67	21	0	Y	N	N	1 photocopier Door open
Town clerk	554	64	28	2	Y	N	N	6 water damage ceiling tiles Door open
Police	537	66	23	1	Y	N	N	Window-mounted air conditioner Door open

*** ppm = parts per million parts of air**

Comfort Guidelines

Carbon Dioxide -	< 600 ppm = preferred 600 - 800 ppm = acceptable > 800 ppm = indicative of ventilation problems
Temperature -	70 - 78 °F
Relative Humidity -	40 - 60%

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March 18, 2005

Location	Carbon Dioxide (*ppm)	Temp. (°F)	Relative Humidity (%)	Occupants in Room	Windows Openable	Ventilation		Remarks
						Supply	Exhaust	
Accountant	506	67	22	0	Y	N	N	Door open
Meeting room-upper level	432	66	21	0	Y	N	N	Door open
Furnace room	466	64	18	0	N	N	N	Oil odors
Assessor	487	67	21	1	Y	N	N	10 water damage ceiling tiles Plants Door open
Technology	508	67	20	1	Y	N	N	Door open

*** ppm = parts per million parts of air**

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